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Case study

Structural behavior for rehabilitation ferrocement plates previously damaged by impact loads

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ABSTRACT

The main objective of this research is to investigate the possibility of using ferrocement concrete to rehabilitee the damaged plates which failed under impact load. The current work presents the comparison between the results of the first crack loads, the ultimate loads and the deflections in the cases of the impact and static loads. Seventeen plates were damaged under impact load [1], which having the dimensions of 500 × 500 and 25 mm thick. The plates were subjected to impact load by 1.15 kg spherical steel ball under its height 1.12 m at the center of the tested plates. The ferrocement plates were reinforced with skeletal steel bars welded galvanized meshes and expanded steel meshes with skeletal steel bars. *The plates* were tested up to failure. The damaged plates were repaired by employing concrete mortar and two layers of galvanized steel mesh (300 * 300 mm) at both the top and bottom faces of the damaged plate and tied with one layer (500 * 500 mm) by means of shear connectors at both top and bottom of the damaged plate by using L screw bolts with imbedded fisher. The rehabilitation plates (500 * 500 * 50 mm) were tested simply supports along its four sides and subjected to central flexural loadings until failure. The obtained results reached emphasized good deformation characteristics, high first crack and ultimate load, high ductility, energy absorption properties, and cracking pattern without spilling of concrete cover that is predominant.

1. Introduction

Ferrocement as a construction technique is defined by ACI committee 549 [2] Ferrocement is type of reinforcement concrete. It commonly composed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. It is lightweight, low cost, durable, weather-resistance, and particularly its versatility comparing to the reinforced concrete [3].

Ferrocement is an excellent material for housing construction. Also Al-Kubaisy and Jumaat [4] studied the possibility of using ferrocement cover in the tension zone of reinforced concrete slabs.

This material is also used in rehabilitation the reinforcement elements such as beams, slabs or walls (Fahmy et al., 1997; [5,6].

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Mourad and Shang [7] used ferrocement jacket in repairing reinforced concrete columns, their test results indicated that using the ferrecement jacket increases the axial load capacity and the axial stiffness of rehabilitation reinforced concrete columns compared to the control columns. Many researches were carried out to study ferrocement elements (beams, slabs and columns) to investigate its behavior under applied loads up to failure.

Ferrocement has been used for many years as a rehabilitation material for reinforced concrete and masonry elements as an alternative to other expensive ones. It allows rapid construction with no heavy machineries or high-level skilled workers, imposes small additional weight and the cost of construction is low. These unique qualities make the ferrocement as an ideal material for rehabilitation. However, one layer of square welded galvanized steel mesh, 300 mm tied with another square layer, 500 mm which were applied at both top and bottom of the failed plate through shear connectors as a developed method of rehabilitation.

The main objective of this paper is to investigate the structural behavior of rehabilitation plates by using ferrocement concrete layers of 10 mm thick at both top and bottom faces. The main objective is to investigate the flexural behavior of rehabilitation plates. This research comprises extensive comprehensive statistical analysis and the comparisons.

2. Experimental study

The experimental program consists of rehabilitation of seventeen Ferro cement plates having the dimensions of 500×500 and 25 mm thick which were previously tested under impact loadings until failure. The failed plates were designed and cast with dimensions of $500 \times 500 \times 25$ m. Plates were designed, mixing and curing according to Egyptian Code of Practices (E.C.P. 203/2007). All damaged plates were repaired by employing two layers of welded galvanized steel meshes with dimensions of 300×300 at both top and bottom of the central region of the plate tying together with another welded galvanized welded mesh of dimensions of 500×500 mm. Tying the top and bottom reinforcing material together by using shear connectors into a rigid cage while failed plate into between. The total dimensions of the repaired plates after rehabilitation 500 mm $\times$ 500 mm and 50 mm thick. All repaired plates were tested under central concentrated flexural loadings along platen of dimensions 100 mm $\times$ 100 mm and 20 mm thick located at the center of all plates until failure. In case of plate FW22 which was reinforced with four layers of welded galvanized steel mesh, additional layer of galvanized welded steel mesh of dimensions 50×50 mm was used as result of separation of the test specimen into two pieces. The main objective of the experimental program is to compare the structural behavior of plates subjected to impact loadings and that rehabilitation by using ferrocement layers and subjected to flexural loadings until failure.

3. Materials, mortar matrix, preparation and casting of test specimens

3.1. Materials

Ordinary Portland cement was used, produced by the Suez cement factory. Its chemical and physical characteristics satisfied the Egyptian Standard Specification (E.S.S. 4657-1/2009).

The fine aggregate used in the experimental program was natural siliceous sand. Its characteristics satisfy the (E.C.P. 203/2007), (E.S.S. 1109/2008) and (ASTM C 33, 2003). It was clean and nearly free from impurities with a specific gravity 2.6 t/m^3 and modulus of fineness 2.7.

Super Plasticizer was used with high rang water reducer HRWR. It was used to improve the workability of the mix. The admixture used was produced by Sika Group under the commercial name of ASTM (Sika viscocrete 20), it meets the requirements of ASTM (Sikaviscocrete20), It meets the requirements of ASTM C494 (type A and F). The admixture is brown liquid having a density of 1.18 kg/l at room temperature. The amount of HRWR was 2.0% of the cement weight.

Polypropylene Fibers PP 300-e3 was used. It was available in the Egyptian markets. It was used in concrete mixes to produced fibrous concrete jacket to improve the concrete characteristics. The percentage of addition was chosen as 900 g/m^3 based on the recommendations of manufacture. The chemical and physical characteristics of Polypropylene Fibers 300-e3 is given in Table 2.

Water used was clean drinking fresh water free from impurities is used for mixing and curing the plates tested according Egyptian Code Practices (E.C.P. 203/2007).

The reinforcing, Welded Metal Mesh: Galvanized welded metal mesh used was obtained from China. We used welded metal mesh as reinforcement to rehabilitee the ferrocement plates. Its chemical and physical characteristics satisfy the

Table 1
Technical Specification and Mechanical properties of Welded Metal Mesh.

Dimensions (mm)	12.5 × 12.5 mm
Weight (gm/m^2)	430
Proof Stress (N/mm^2)	400
Ultimate Strength (N/mm^2)	600
Ultimate Strain × 10-3	1.25 × 1.5 mm
Proof Strain × 10-3	1.17